OWOW Briefing
March 15, 2018
Oregon Marine Waters Listing

Deliberative Process / Ex. 5

Oregon Listing Background:

Considerations for 303(d) Listing Actions

Relevant federal regulations

- **40 CFR 130.7(b)(3):** "For the purposes of listing waters under [HYPERLINK "https://www.law.cornell.edu/cfr/text/40/130.7" \l "b" \o "§ 130.7(b)"], the term "water quality standard applicable to such waters" and "applicable water quality standards" refer to those [HYPERLINK "https://www.law.cornell.edu/definitions/index.php?width=840&height=800&iframe=true&def_id=8e9d4fc1a200f462c0cc589c00dac71d&term_occur=1&term_src=Title:40:Chapter:I:Subchapter:D:Part:130:130.7" \o "water quality standards"] established under section 303 of the [HYPERLINK "https://www.law.cornell.edu/definitions/index.php?width=840&height=800&iframe=true&def_id=83b8c1565fcb0034d12b698603f47844&term_occur=3&term_src=Title:40:Chapter:I:Subchapter:D:Part:130:130.7" \o "Act"], including numeric criteria, narrative criteria, waterbody uses, and antidegradation requirements."

- **40 CFR 130.7(b) (5):** "Each [HYPERLINK "https://www.law.cornell.edu/definitions/index.php?width=840&height=800&iframe=true&def_id=2dd85978b57d4ab93460318 70a2650c5&term_occur=9&term_src=Title:40:Chapter:I:Subchapter:D:Part:130:130.7" \o "State"] shall assemble and evaluate all existing and readily available water quality-related data and information to develop the list required by [HYPERLINK "https://www.law.cornell.edu/cfr/text/40/130.7" \l "b_1" \o "§§ 130.7(b)(1)"] and 130.7(b)(2). At a minimum "all existing and readily available water quality-related data and information" includes but is not limited to all of the existing and readily available data and information about the following categories of waters: . . .

  (ii) Waters for which dilution calculations or predictive models indicate nonattainment of applicable [HYPERLINK "https://www.law.cornell.edu/definitions/index.php?width=840&height=800&iframe=true&def_id=8e9d4fc1a200f462c0cc589c00dac71d&term_occur=3&term_src=Title:40:Chapter:I:Subchapter:D:Part:130:130.7" \o "water quality standards"];

  (iii) Waters for which water quality problems have been reported by local, [HYPERLINK "https://www.law.cornell.edu/definitions/index.php?width=840&height=800&iframe=true&def_id=2dd85978b57d4ab93460318 70a2650c5&term_occur=11&term_src=Title:40:Chapter:I:Subchapter:D:Part:130:130.7" \o "state"], or federal agencies; members of the public; or academic institutions. These organizations and groups should be actively solicited for research they may be conducting or reporting. For example, university researchers, …the National Oceanic and Atmospheric Administration, …are good sources of field data; …."

<u>Applicable Approved State Water Quality Standards</u>

- <u>Oregon waters</u>: Oregon water quality standards apply to all waters within Oregon's boundaries, including "ocean waters" or "all oceanic, offshore waters outside of estuaries or bays and within the territorial limits of Oregon" (OR OAR 340-041-0020).
- <u>Numeric marine pH criteria</u>: Marine waters may not fall outside the range of 7.0 to 8.5 pH units (OR OAR 340-041-0021).
- <u>Narrative criteria for aquatic life designated uses</u>: Aquatic life designated use must not be impaired. Narrative Criteria that are relevant are listed below:

  OAR 340-041-0011 – Biocriteria:

  "Waters of the State must be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities."

  OAR 340-041-0007 - Statewide Narrative Criteria:

  "(1) Notwithstanding the water quality standards contained in this Division, the highest and best practicable treatment and/or control of wastes, activities, and flows must in every case be provided so as to maintain dissolved oxygen and overall water quality at the highest possible levels and water temperatures, coliform bacteria concentrations, dissolved chemical substances, toxic materials, radioactivity, turbidities, color, odor, and other deleterious factors at the lowest possible levels."

  "(10) The creation of tastes or odors or toxic or other conditions that are deleterious to fish or other aquatic life or affect the potability of drinking water or the palatability of fish or shellfish may not be allowed; …."

- It should be noted that Oregon has not developed or adopted listing methodologies to implement these narrative criteria for marine waters. Oregon has created listing methodologies for the interpretation of other narrative criteria, including aquatic weeds or algae and biocriteria for freshwater, but no means of implementing the biocriteria or statewide narrative standards for marine waters have been developed (ODEQ, 2014).

Relevant EPA 303(d) listing guidance

- EPA 2006 IR guidance: "States must identify all pollutants that are *known* (emphasis added) to be causing the impairment of a segment." (page 63) "....if a designated use is not supported and the segment is impaired or threatened, the fact that the specific pollutant is not known does not provide a basis for excluding the segment from Category 5. These segments must be listed unless the state can demonstrate that no pollutant(s) causes or contribute to the impairment. Prior to establishing a TMDL for such segments the pollutant causing the impairment must be identified." (page 60)
- EPA 2010 OA Memorandum: Integrated Reporting and Listing Decisions Related to Ocean Acidification: "EPA encourages coastal States to start developing assessment methods for evaluating marine waters based on OA impacts using their existing marine pH and biological (narrative and numeric) WQC. EPA reaffirms that States must list waters not meeting water quality standards, including marine pH, based on existing and readily available water quality-related data and information. Consistent with existing IR guidance, EPA also supports the use of predictive modeling and other non-site-specific data such as remote sensing data, land use analysis and knowledge about pollutant sources and loadings to make assessment decisions..."

Oregon Listing History

Oregon 2010 CWA 303(d) list submittal

- EPA solicited comments on proposed additions to the Oregon list in March, 2012.
- The Center for Biological Diversity (CBD) submitted comments as well as additional references, requesting EPA include all coastal waters as impaired on Oregon's list based on general studies about ocean acidification as well as information concerning Northwest oyster hatcheries experiencing low recruitment rates.
- EPA determined that there was insufficient evidence demonstrating non-attainment of Oregon's marine pH criteria and/or state-wide narrative criteria related to aquatic life designated uses to warrant listing any coastal waters as impaired or threatened due to parameters associated with ocean acidification.
- CBD filed a lawsuit challenging EPA's findings and seeking a remedy to require listing for impairments due to parameters associated with ocean acidification. EPA's decision not to list was upheld in February 2015.
- The District Court deferred to EPA's technical expertise in its analysis of existing information and upheld EPA's decision. Specific points of EPA's rationale that the Court found reasonable were: (1) existing laboratory studies did not reflect natural conditions so EPA reasonably did not rely on extrapolation of those studies to Oregon waters; (2) Netarts Bay hatchery study could not be extrapolated to distant Oregon or Washington waters due to variable conditions in nearshore bays and coastal waters and because data were collected inside the hatchery building, not in ambient water; (3) and that, although there were studies showing a link to aragonite saturation levels and biological effects, there were no existing studies showing impacts on resident biological communities.

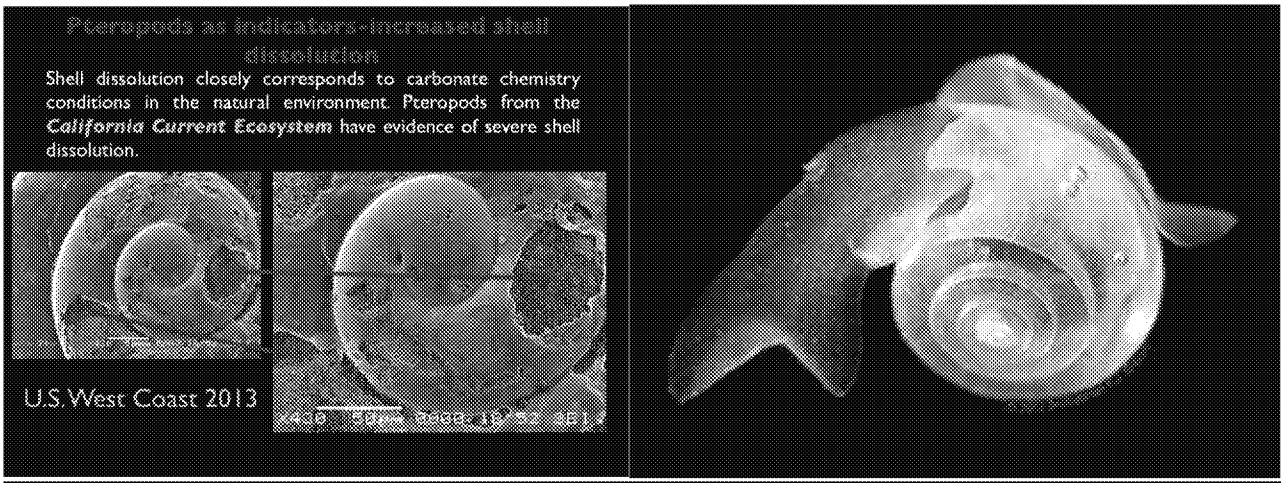
<u>Oregon 2012 CWA 303(d) list submittal</u>

- Oregon did not list for any impairments for parameters related to ocean acidification and only used pH data to respond to comments pertaining to ocean acidification.
- EPA partially approved and partially disapproved Oregon's 2012 list. EPA assessed all of the readily available data and information that Oregon failed to consider and proposed adding 332 waters to OR's list for a variety of parameters.
- EPA did not propose the addition of marine waters due to impairment of the aquatic life narrative related to ocean acidification. Instead, EPA solicited public comments specifically about ocean acidification and sought any additional data during our public comment period, which was open from December 16, 2016 to April 3, 2017.
- EPA received ocean acidification related comments in writing from four stakeholders, including CBD, Oregon Wild, ODEQ and environmental staff from the Coquille Tribe. CBD supported the use of extrapolated data, submitted 22 pages of comments, as well as pH data and over 140 literature articles, and urged that at least six different locations off the Oregon coast should be listed. CBD proposed listing these sites for non-attainment of pH criteria on the basis that the pH levels recorded at these locations were at levels found to result in biological impacts. However, the pH measurements of all of the sites were well within the numeric OR pH WQS, so EPA determined listing was not appropriate. Oregon Wild also supported the extrapolation of data from outside state waters to list state coastal waters as impaired. ODEQ urged that it would be inappropriate to use data from outside state waters, and inappropriate to use aragonite saturation information to interpret the narrative standard. Although not in its comment letter, ODEQ staff have orally indicated that given the planktonic nature of pteropods, the data should not be used for listing even if pteropods were to be collected within state jurisdiction. An environmental staff member for the Coquille Tribe, commented that this should be addressed through WQS and was not sure a listing would be effective, giving the potential for air sources outside ODEQ's jurisdiction.

Science Background: What has changed since 2010? The literature cited below represents the most current "existing and readily available water quality-related data and information," which EPA reviewed to develop the impaired waters list. Many of the sources were referenced by CBD in their comment letter; EPA also reviewed additional literature published after the comment period ended.

Deliberative Process / Ex. 5

Figure 1: Pteropod dissolution. Feely et al., 2015; smithsonianmag.com



a. Aragonite is a carbonate mineral that is precipitated by pteropods and certain other organisms (e.g., corals) to form their shells/skeletons/structures. Several studies have shown that the aragonite saturation state is a better early indicator of the impacts of OA than pH (Waldbusser et al., 2014; Waldbusser et al., 2015).
b. Generally, in supersaturated conditions, where the aragonite saturation is greater than 1, pteropods and other shell building organisms exhibit no signs of shell dissolution (Weisberg et al., 2016). Waters with an aragonite saturation value of 1 or less are generally considered to be corrosive, i.e., water chemistry in which aragonitic shells dissolve rather than precipitate. Field studies (Bednarsek et al. 2014) and laboratory experiments (Busch et al., 2014) demonstrate that such reduced saturation states result in dissolution of organisms' shells. Recent research has determined a "shell dissolution threshold" of 1.1, above which signs of shell stress are not observed. At the threshold of 1.1, approximately 50% of pteropods are affected by dissolution. Below a saturation state of 0.8, dissolution becomes more severe (Bednarsek et al., 2017a, 2017b). Other research has documented saturation states of up to 1.7 being linked to commercial production failures of larval oysters (Barton et al., 2012).
c. The "shell dissolution threshold" of 1.1 -- at which 50% of pteropods are affected -- generally occurs around a pH of 7.80-7.85, which is well within the range of the Oregon WQS (Bednarsek et al., 2017a). This indicates that the approved numeric pH standard alone does not fully characterize the full range of measurable biological impacts on the State's designated uses.
d. Aragonite saturation values of 1 or lower have been repeatedly observed in the marine waters of Washington and Oregon, in the coastal ocean (Feely et al., 2008; Harris et al., 2013), the estuarine water of Puget Sound and the Columbia River (Feely et al., 2010, 2016; Reum et al., 2014), while pH values remain well within the criteria.
e. Researchers argue that pteropod shell dissolution should be used as an ecological indicator and early indicator of ocean acidification conditions. Using an ecosystem indicator screening framework for indicators of marine ecological integrity, shell dissolution scored very highly compared to other potential indicators (Bednarsek et al., 2017a). This suggests that it should be considered as an indicator of ecological integrity, which describes "the ability of a system to support and maintain a community of organisms and ecosystem functions within a natural range of variability, and to withstand or recover from disturbances" (Bednarsek et al., 2017a; Williams et al., 2013).
f. Pteropod dissolution may signal similar declines in the health and productivity of other taxa with similar biology, ecology and distribution, and therefore ecosystem level implications (Bednarsek et al., 2017a).
g. The commercial and recreational shellfisheries are a $48 million industries in Oregon, which have the potential for similar dissolution impacts, some of which are already being seen (Barton et al., 2012; Sylvia and Davis, 2016).

<u>2. Research regarding local conditions reveals why we are seeing effects here first. Waters in the Pacific Northwest are particularly vulnerable to ocean acidification because of coastal upwelling and ocean currents.</u>

a. The waters of the Pacific Northwest, including Oregon, are vulnerable to ocean acidification, because prevailing winds that blow southward during spring and summer push surface waters away from the coastline. As the surface waters are displaced, the deep waters rich in CO_2 and low in dissolved oxygen are pulled to the surface in a process known as upwelling (Feely et al., 2008; Juranek et al., 2009; Harris et al., 2013).
b. Upwelling events offshore from Oregon primarily occur in the summer and early autumn, and last for approximately one to five weeks (Bednarsek et al., 2014).
c. When these events occur the aragonite saturation state of the water column decreases and the chance of adverse impacts on aquatic life increases (Bednarsek et al., 2014). *See Figure 2 below (Juranek et al., 2009)*

Figure 2: From Juranek et al., 2009

d. Pteropods do not appear to demonstrate adaptation to OA events with increased exposure, so are most vulnerable in areas of frequent and prolonged corrosive events (Bednarsek et al., 2017b).
e. Although upwelling has always been present along the west coast of the U.S. due to the prevailing northerly winds, the corrosiveness of upwelled waters has increased significantly since pre-industrial times (Bednarsek et al., 2014).

f. The waters that upwell along the west coast are relatively old and have characteristics that have been dated to be roughly 50 years old, depending on the exact depth at which the upwelling occurs, which varies with the strength and wind angle (Feely et al., 2008).

3. There are now biological data from wild, native population assemblages available. Data and information published by Bednarsek et al., 2014, supplemental data provided by UW/NOAA, and others demonstrate shell dissolution of pteropods off the coast of Oregon and that shell dissolution corresponding to aragonite under-saturation has doubled since pre-industrial conditions and is projected to triple by 2050.

a. In 2014, Bednarsek et al. released a widely publicized study on the shell dissolution of pteropods off the coast of Washington, Oregon, and California.
b. Pteropods are an important prey group for ecologically and economically important fishes, bird, and whale diets (Bednarsek et al., 2014)
c. For Oregon, the 2014 Bednarsek et al. pteropod samples were collected from mid-August through early September at six stations at locations ranging from 6.5 miles to 85 miles from the Oregon shoreline (approximately 3.5 to 82 miles outside state waters.)
d. The stations with the highest proportion of individuals exhibiting signs of dissolution were located closest to shore. *See Figures 2-5.*
e. The study found that 53% of onshore and 24% of farther offshore pteropods had severe dissolution damage.
f. The authors used hindcast modeling based on the assumption that the dissolved inorganic carbon in the water correlated to air-sea CO_2 differences following Harris et al., 2013, to estimate that the incidence of severe pteropod shell dissolution has doubled in near shore habitats since pre-industrial conditions across the study area and is projected to triple by 2050.
g. Additional unpublished data from Bill Peterson (NOAA, NW Fisheries Science Center) corroborate the nearshore results of Bednarsek et al., 2014, confirming the pattern with a decline in pteropods at a station located 9.1 km (5.65 mile from the Oregon shore; approximately 2.65 miles outside state waters.)
h. Several additional lab and field studies have shown adverse impacts to shellfish from corrosive conditions.
    1. A number of studies document a close positive correlation between the rate of calcification and the aragonite saturation state. As the aragonite saturation state decreases, so does the rate of calcification (Feely et al*.,* 2012)
    2. Mollusks (such as mussels, clams, and oysters) have been shown to be sensitive to ocean acidification, and both early life stages and adults have shown reduced calcification, growth, and survival when exposed to corrosive conditions (e.g., aragonite saturation less than 1) (Nature Climate Change 10.1038)
    3. Hatchery and laboratory studies have shown that oyster larvae experience conditions detrimental to their development and growth at an aragonite saturation level of 1.7 (Waldbusser et al*.,* 2013).
    4. Laboratory studies by Miller et al., 2016, demonstrate impacts on early stages of Dungeness crabs, including delays in hatching at a pH of 7.1, and significantly reduced zoeal survival at a pH of 7.5 and below.
    5. Bednarsek et al., 2016, recorded increased pteropod mortality with increased dissolution.
    6. Recent studies by both Bednarsek et al*.,* 2016, and Lischka *et* al., 2011, document cumulative effects of decreased pH, deoxygenation and increased ocean temperatures which negatively affected survivability of pteropods.
i. The graphs below (Figures 3-5) show the relationship between pteropod dissolution and station depth; percent of water column with aragonite saturation less than 1 and station depth; and dissolution of pteropods and percent of water column undersaturated.

Figure 3: Percent Pteropod Damage with Station Depth, from Bednarsek et al., 2014; Feely et al., 2015.

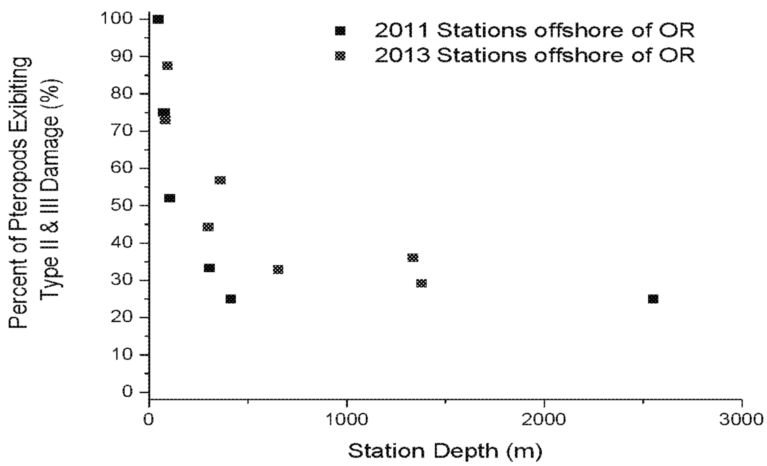


Figure 4: Percent Water Column Undersaturated with Station Depth, from Bednarsek et al., 2014; Feely et al., 2015.

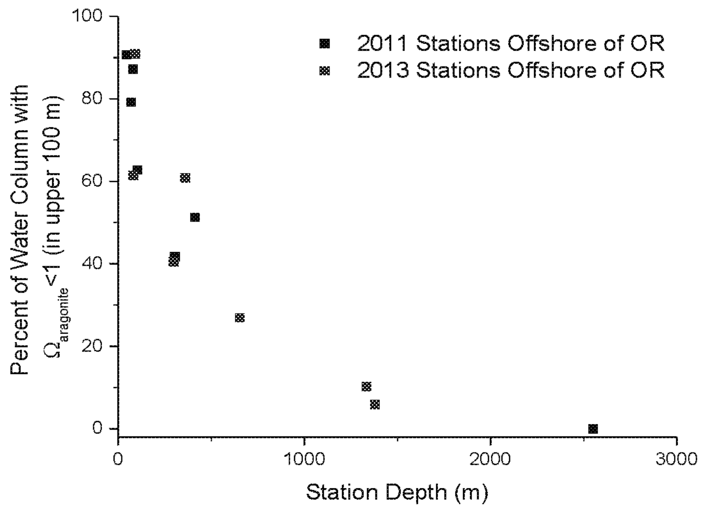


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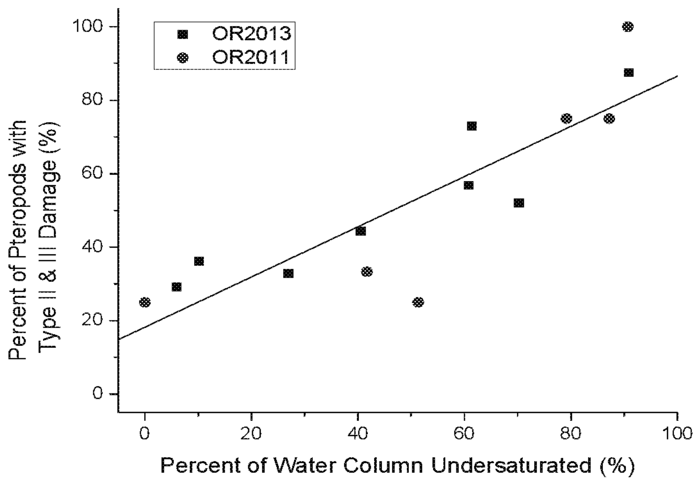
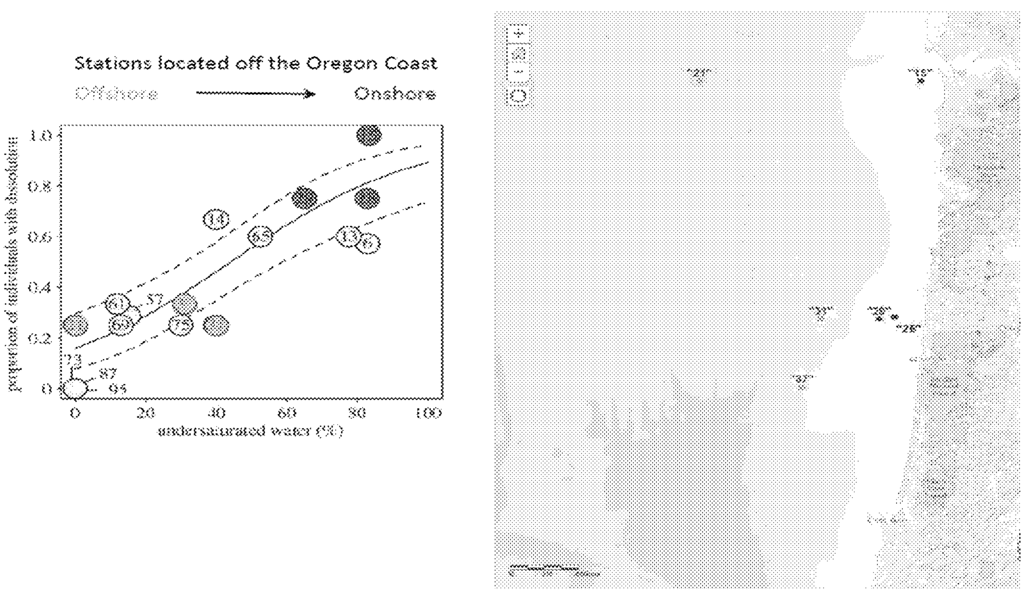
Figure 5: Percent Pteropod Dissolution vs. Percent Water Column Undersaturated



j. Feely et al., 2015 recorded an increase in dissolution along sampling transects with the greatest dissolution found within closest proximity to the Oregon coast. This correlates with a decrease in aragonite saturation, a shoaling of the aragonite saturation horizon and an increase in the percent of the water column that is undersaturated, up to 100% at some stations (Figure 6).

Figure 6: Based on data from Feely et al., 2015. Pteropod dissolution increases along transects from offshore to onshore, with increased percent water column saturated.



k. Feely et al., 2015, data demonstrate an aragonite saturation state of less than 1, which is corrosive to pteropods, in 73% of observations in state waters.
l. It is reasonable to assume that the relationship between decreased aragonite saturation state and increased shell dissolution also exists in state waters. It is also therefore reasonable to conclude that the trend of increased dissolution with closer proximity to shore will continue into Oregon state waters, where the water column has been demonstrated to be undersaturated, in some cases up to 100%.

Discussion:

Deliberative Process / Ex. 5

Deliberative Process / Ex. 5

Deliberative Process / Ex. 5

Deliberative Process / Ex. 5

Deliberative Process / Ex. 5

Deliberative Process / Ex. 5

Deliberative Process / Ex. 5

Region 10 Recommendation

Deliberative Process / Ex. 5

Deliberative Process / Ex. 5

Deliberative Process / Ex. 5

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